Space Weather Technical Forecast

Issued on Friday, 14 July 2023 at 13:19 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Minor/Moderate R1/R2 Blackouts Likely throughout. Peak Chance of G1/G2 Minor/Moderate Geomagnetic Storms in next 24 hours.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with X-ray flares recorded at GOES16 showing isolated M-class activity, firstly an M2.1 from AR3372 in the northeast at 13/1920UTC, and secondly an M1.0 from AR3363 in the southwest at 14/0936UTC. The second event appears to have produced a CME by possibly triggering an adjecent filament eruption. This may yet bear an Earth-directed component but has yet to be analysed. This pattern of activity was not unexpected given that these two sunspot regions account for much of the complexity on the Earth-facing side of the Sun.

There are up to nine sunspot regions on the disc at the time of writing, with two new unnumbered regions becoming visible in the far east, as AR3361 became difficult to discern in the far northwest. By far the largest and most complex are AR3372, which manifests as a Eko/Beta-Gamma-Delta with minor proliferation surrounding its trailing penumbral spot; and AR3363 in the southwest, which is showing as a Dki/Beta-Gamma-Delta, also with peripheral spots around the eastern end of the main penumbral group. Both of these groups contain at least one candidate for Mt Wilson delta spots. AR3367 in the northwest historically had some evidence of deltas, however this group has shown a decaying trend in recent hours, finishing as a Dsi/Beta with a spreading and shrinking tendency.

The Sun has been relatively prolific in producing Coronal Mass Ejections (CMEs) in the period, however most appear to variously arise from western limb prominences; high solar latitudes and perhaps a large region inferred as lying diametrically opposite the sub-Earth point (with some evidence on soundings for a large group here). None of these recent CMEs have been identified as carrying an Earth-directed component, however confidence in this assertion is lowered given their sheer number and cross-pollution in analysis.

Solar Wind / Geomagnetic Activity: The solar wind, as recorded by DSCOVR at L1, showed a mostly small magnitude but disturbed trace. The causes of the unsettled behaviour are not definitive, but may be a combination of a weak 10 July CME arrival and developing minor fast wind.

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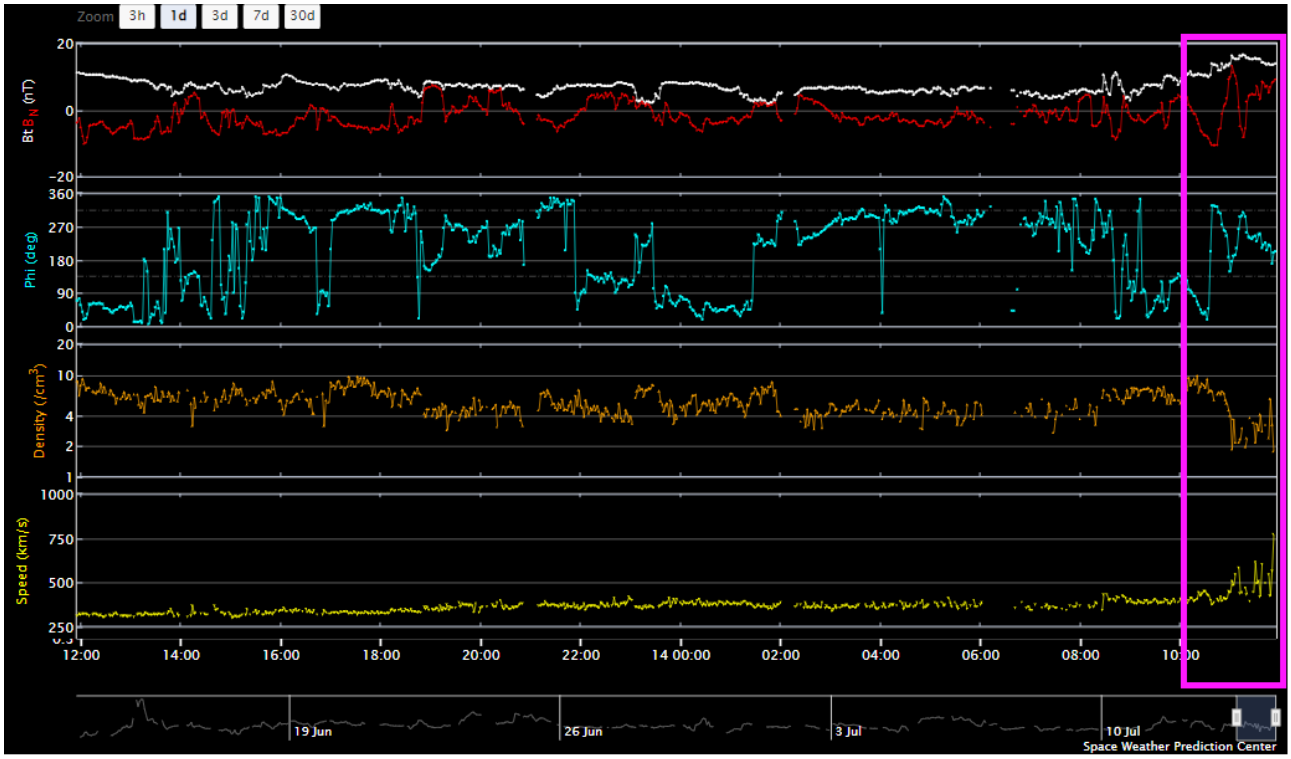

Figure 0: STOP PRESS - Latest available STEREO A MAG and PLASTIC measurements, which show a very recent more convincing signature for a negative polarity fast wind (presumably from CH23/-). This does materially change the forecast, but is an altered ratioanle. This should reach Earth around the turn of the coming UTC day Friday into Saturday, and may yet combine with any 11 July CME.

The solar wind speed was initially on a level trend near 300km/s, but showed a discontinuity upwards to nearer 350 at 13/1530UTC, remaining nearer this level for the rest of the period. The solar wind density rose to a concurrent peak of 25ppcc before falling back to single figures ppcc. The IMF also peaked at a similar time at 14nT before moderating over the remainder of the 24 hours. The north-south component, Bz, showed a range of between +12 and -11nT, generally drifting from the former to the latter extremes, before a more typical small-scale trace resumed from around 14/0530UTC. Because of the sudden onset and the rough sinusoidal Bz trace, this was perhaps a transient, with the phi angle generally also restless and not showing any sustained negative orientation (towards the Sun) until late in the period, which may indicate a segue into the commencement of the CH23/- fast wind.

The net result of the above solar wind measures was provisionally Quiet to Active geomagnetic activity, with a peak Kp of 3+ in the 03-06UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has been at Background levels.

High energy electron flux (greater than 2MeV) was at Normal Background to Moderate, peaking at 443pfu at 13/1830UTC. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a decreasing trend. A fluence of 8.81e6 pfu was recorded at 14/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is Likely, with the daily risk of isolated M-class flares roughly partitioned equally between the two largest and most complex regions on the disc. These remain on the front-side throughout.

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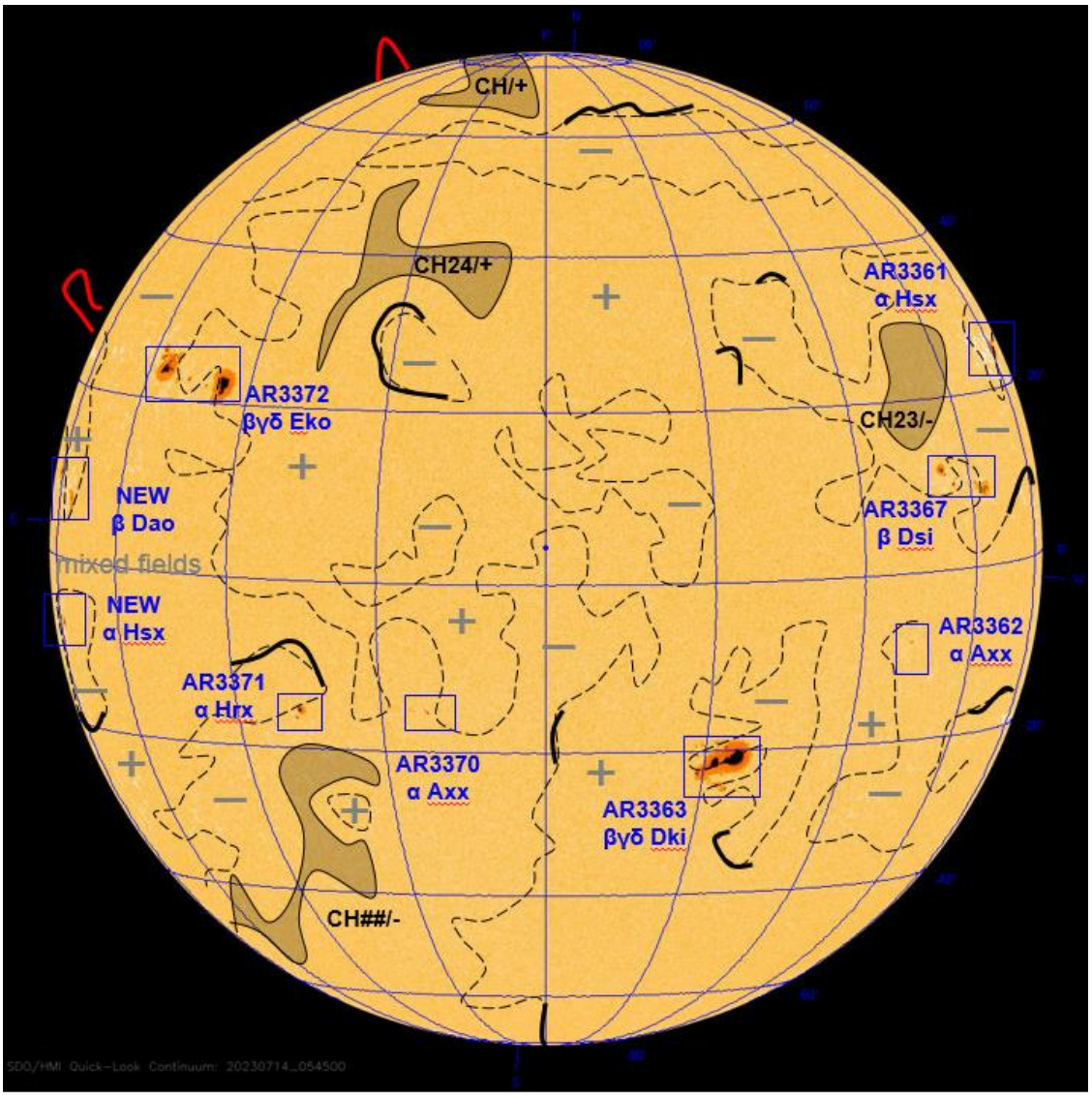
Solar Wind / Geomagnetic Activity: The geomagnetic forecast is relatively low confidence, however it remains the case that activity should peak during the first half of the four-day forecast, with the 11 July filament CME glancing and perhaps combining with CH23/-. Any possible tenuous successor coronal hole is highly uncertain but not likely to be significant. There is a Chance of G1/G2 on day one, Friday 14 July, falling to a mainly Quiet forecast from Sunday 16 July.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a Slight Chance of reaching the S1/Minor Storm threshold through the period, should any larger flares occur.

High energy electron flux (greater than 2MeV) is likely to remain near present levels in the near-term. While the low confidence in the longer range carries over from uncertainties in the geomagnetic forecast, on balance there is assessed to be a Chance of Active fluence in the wake of any CME and CH23/-.

Figure 1. Solar Analysis Valid 14/0545UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There remains one low confidence CME in the forecast: a glancing arrival from the 11 July filament eruption, with a most likely pass of 1AU around 14/1600UTC.

The coronal hole forecast carries relatively high uncertainty. Solar winds in the past 24 hours are suggestive of some enhancement, however this has been both minor in magnitude and hesitant, and may comprise a mix of transient and fast wind sources (perhaps CH23/- and the 10 July CME) with the phi angle in particular remaining changeable, and with some suggestion of a sinusoidal variation in Bz for a time.

Regarding CH23, on the previous rotation a strong connection occurred, with solar winds peaking over 600km/s, however the CH appears much-reduced and fragmented on this occasion. This weaker arrival is perhaps corroborated by a slight increase in the solar wind at STEREO A in the past 24 hours, with the solar speed increasing from around 300km/s to near 400km/s. MOSWOC Enlil favours a stronger connection to around 500km/s, albeit contaminated with the CME arrivals.

Whatever the attained magnitude, the duration of the fast wind is likely to be short, and should most likely ease through the course of the UTC weekend. Confidence in the forecast beyond this is somewhat lower still as there may be a diffuse equatorial coronal hole succeeding CH23/-, although this appears less clear than in recent days, and the open field lines may have now closed.

Overall, the risk of G1/G2 should peak within the current UTC day should the CME arrive, with a slight tail into Saturday 15 July should it be of more glancing incidence. Beyond this, a largely Quiet forecast is suggested, although there remains a question mark as to any succeeding diffuse fast wind.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	40	10	1	1
Strong	**G3**	No	5	5	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/2335	Partial halo and asymmetric halo shock	Filament S of AR3363	SE	870km/s	14/1600UTC	Glancing, low confidence

Figure 2: Latest MOSWOC Enlil and ensemble showing highlighted in magneta the possible 11 July southern disc filament CME. Shown prior to this is the diffuse response from the 10 July CME, which is likely to have been observed within the current reporting period to little effect.

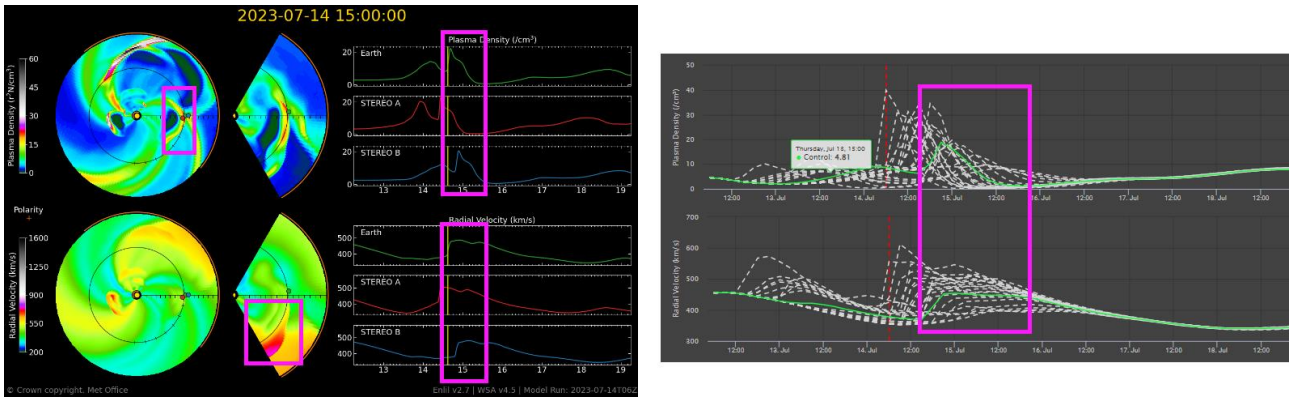
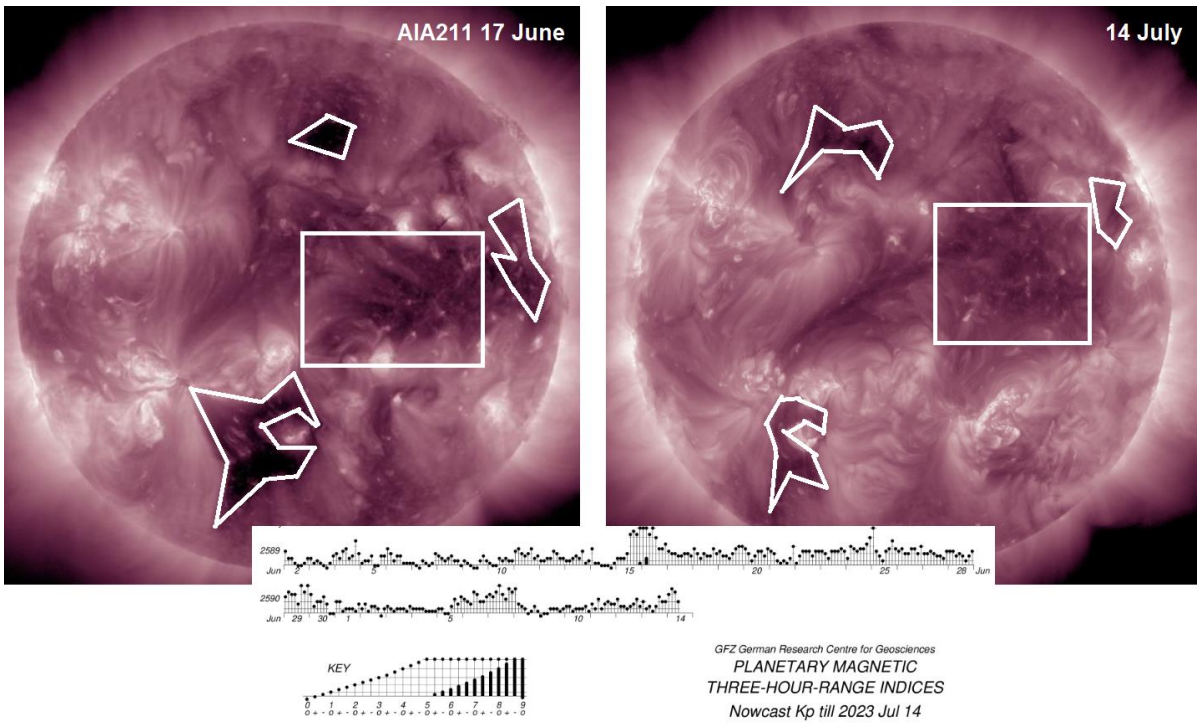


Figure 3: Comparison between current coronal holes (right) and those from the past rotation – CH23/- can be seen upper right in both images, with a questionable contribution from a very diffuse region shown boxed to its east. Whether this following fast wind occurs or not, activity is likely to be relatively subdued.



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Radio Blackouts - X-Ray Flares:

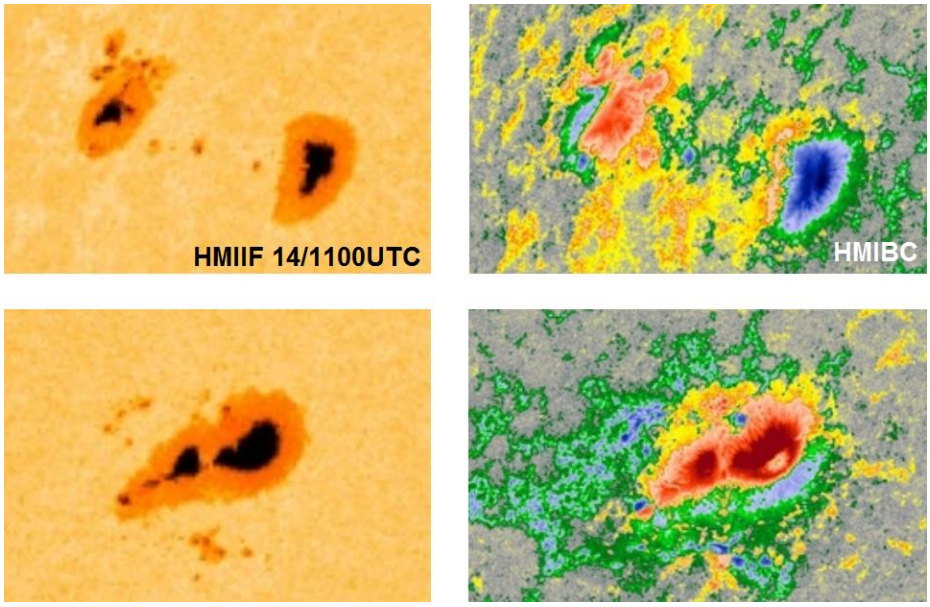
Solar activity in the last 24 hours has been Moderate, with a M2.1 flare from AR3372 peaking at 13/1920UTC. Coupled with a later M1.0 flare from AR3363, the other large and complex spot, this has given a fair account of the daily risk faced from the current cohort of active regions.

The balance of regions likely to occupy the front side in the period is unclear, as while up to three soon depart including the previously delta spot-containing but now fading AR3367, there are far-side soundings that suggest the arriving northeastern limb in particular could see a train of returning regions, potentially eventually including a large CME-producing one that is facing directly away from Earth at present.

Flare risks are currently judged to lie near the suggested Zurich historic raw value for the disc at 60% M and 5% X. While there are Mt Wilson deltas present that would not feature in this assessment, there are other observed trends that serve to lower the risk, such as the recent history, general slow pace of changes and the regions' maturity. Departing regions are likely to be at the very least matched and very possibly exceeded by eastern horizon arrivals, although the risks are held constant for now.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	Yes	60	60	60	60
Very Active	**R3 to R5 X Class**	No	5	5	5	5

Figure 4: HMIIF and HMIBC of AR3372 (top, NE quadrant) and AR3363 (bottom, SW quadrant), showing possible small Mount Wilson delta spots within. Both spots are roughly 1000mhs in size



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is currently near background. It has shown some minor enhancements in response to some of the past week's M-class flares, however these have fallen comfortably short of S1.

There is a daily Slight Chance of GOES16 protons rising towards the S1 Minor Radiation storm level, given any significant flaring from the spots on the western limb. The next significant contributor(s) then lie nearer the eastern limb, perhaps keeping the daily risk roughly constant - as the current western regions cross the horizon onto the far side and rotate away, all while the eastern groups progress.

Radiation Storms **Probability (Exceedance)**	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)** **(%)**	**Day 2 (00-24 UTC)** **(%)**	**Day 3 (00-24 UTC)** **(%)**	**Day 4 (00-24 UTC)** **(%)**
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) at GEO is varying diurnally between Background and Moderate levels. The next influx of electrons into the Van Allen belt is expected to occur with the combined effect of the CME and fast wind enhancement. Observed flux is expected to rise to Moderate, perhaps High levels as a result from later in the UTC weekend.

The associated 24-hour fluence is expected to remain below the Active threshold, with REFM giving a good guide in the absence of any enhancement, albeit by default given its lack of knowledge of any intervening CME. All considered, electron fluence will most likely to remain below the Active threshold (1e8 integrated pfu) but with a rising trend from day 3 (Sunday 16 July), leading to an eventual Chance of the Active threshold being breached during day 4 (Monday 17 July).

GEO Electron Environment **Probability (Exceedance)**	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)** **(%)**	**Day 2 (00-24 UTC)** **(%)**	**Day 3 (00-24 UTC)** **(%)**	**Day 4 (00-24 UTC)** **(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	20	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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